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ABUNDANCE OF ARTHROPODS INHABITING DUFF AND SOIL AFTER PRESCRIBED BURNING ON FOREST CLEARCUTS IN NORTHERN IDAHO[1]

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ABSTRACT

Abundance of some arthropods inhabiting the duff and soil on three clearcut areas that were prescribed burned was investigated in northcentral Idaho. Generally more arthropods were present and more taxa were represented on older burns. In duff samples, the Acarina, Chilopoda, Thysanoptera, Protura, and Thysanura were most numerous in more recent burns. Acarina comprised 77 percent of the fauna in the duff samples. Soil samples collected before mid-July contained about 90 percent of the total number of individuals--mostly immatures--especially on the oldest burn. The most abundant arthropod in the soil samples on the oldest burn was the carabid Amara erratica *(Sturm). Because of the abundance of this carabid and its seed-eating behavior, it is recommended that direct seeding of western white pine (*Pinus monticola *Dougl.), and perhaps of other conifers, be done the first or second season after prescribed burning.*

Wildfires are known to reduce the abundance of soil animals--at least temporarily. In a longleaf pine (*Pinus palustris* Mill.) forest in the Southeast, Heyward and Tissot (1936) found soil microfauna (mostly arthropods) to be 11 times more abundant in both the A_0 horizon and the upper 2 inches (5.08 cm.) of mineral soil on unburned areas than in respective soil depths on burned areas. A study of soil arthropod populations in the Pine Barrens of New Jersey (Buffington 1967) showed significantly higher populations of arthropods on unburned as compared to burned areas. Buffington's samples from the unburned areas were usually richer in both numbers of taxa and of individuals. In

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[1] Based on part of a thesis entitled "Biotic factors influencing direct seeding of western white pine *(Pinus monticola)*" prepared by the junior author in partial fulfillment of the requirements for a master's degree in forestry at the University of Michigan.

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Finland, Huhta and others (1967) demonstrated that burning-over of residues (slash) following tree harvesting was very destructive to all groups of soil animals. They noted that many groups were permanently affected, but that other animal groups might find conditions more favorable later and experience a more or less temporary population resurgence if the organic layer was deep enough to remain at least partly unaffected by the fire.

It is common practice in the forests of the northern Rocky Mountains to broadcast burn slash and unmerchantable trees following logging. These fires consume varying levels of duff[3] exposing proportionate amounts of mineral soil. Partial or complete exposition of mineral soil is desirable as a seedbed for germination of many species of forest tree seed and as a site for planting coniferous seedlings. Burning also removes vegetation that competes with developing young trees. Logging followed by prescribed burning usually also provides a desirable habitat for many vertebrates, particularly ungulates--a habitat that often is more favorable than that provided by dense forest cover. At the same time, fires influence the habitat of invertebrates living in the duff and upper layers of mineral soil.

In this study, our objectives were to (a) determine the relative abundance of arthropods inhabiting the duff and upper mineral soil 1, 2, and 3 years after clearcut areas were prescribed broadcast burned, and (b) identify those arthropods that might be a threat to successful coniferous regeneration by direct seeding.

STUDY AREA AND PROCEDURE

We conducted our study[4] during 1963 in the Musselshell area of the Clearwater National Forest in northern Idaho. Ecologically, most of the area is in the *Thuja plicata-Pachistima myrsinites* habitat type; a smaller portion on the more severe southerly and southwesterly exposures is in the *Abies grandis-Pachistima myrsinites* habitat type.[5] The topography of this area is characterized by rolling low hills having a maximum relief of about 200 feet (60 m.); slopes vary from near zero to about 30 percent.

Three areas, which range in size from 50 to 1,900 acres (20 to 769 ha.) were selected for study. Each had been clearcut, and then prescribed burned in the late summer or early fall of 1960, 1961, and 1962, respectively. The intensity and depth of burning varied somewhat both within and between the three areas.

By 1963, the vegetation on the three burns was quite variable. On the 1960 burn, the most abundant types of vegetation found were grasses, sedges, and mosses; occasionally, some thistles (*Cirsium* spp.) and fireweeds (*Epilobium* spp.) were found (fig. 1). On the 1961 burn, thistles and fireweeds were predominant, interspersed with other herbaceous plants. On both the 1960 and 1961 burns, shrubs were abundant but they were small and inconspicuous. On the 1962 burn, there was virtually no living vegetation during the early spring of 1963 (fig. 2), but some thistles invaded the area during the late spring and early summer.

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[3] Forest litter and other organic debris in various stages of decomposition, on top of the mineral soil, typical of coniferous forests in cool climates where rate of decomposition is slow, and where litter accumulation exceeds decay.

[4] This study is only a portion of a more comprehensive study concerning the biotic factors that influence the direct seeding of western white pine (*Pinus monticola* Dougl.). The overall study was established by and is under the supervision of Raymond J. Boyd, Associate Silviculturist, stationed in Moscow at the Forestry Sciences Laboratory, maintained in cooperation with the University of Idaho.

[5] Daubenmires' classification (1968).

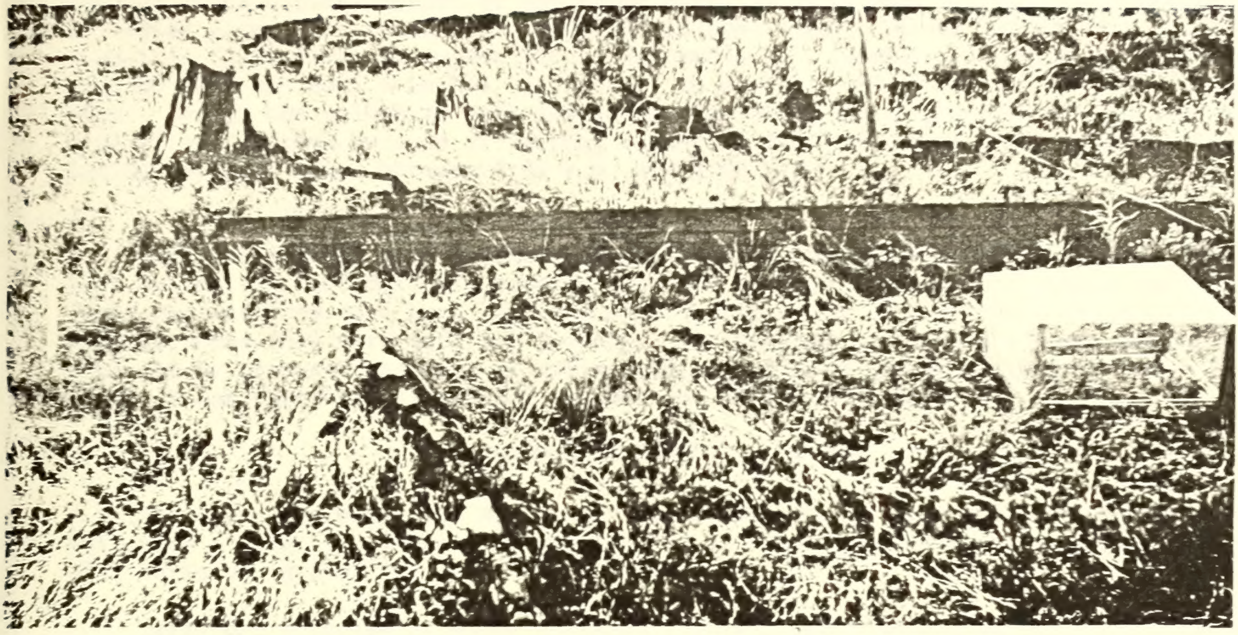

Figure 1.--Portion of clearcut burned in 1960 as seen in early spring of 1963. Grasses, sedges, and mosses are the predominant vegetation; thistles and fireweed were less abundant. There are also quite a lot of small and inconspicuous shrubs hidden from view by the other vegetation. Stakes and exclosure seen in photo were used for another study.

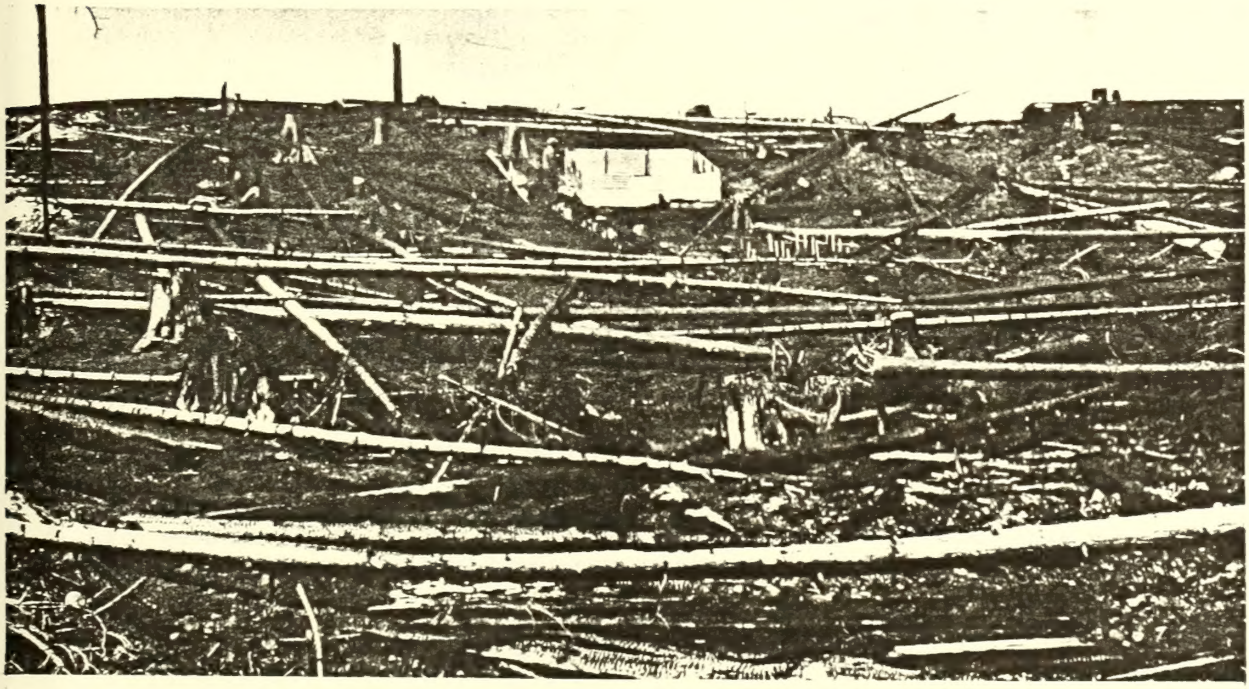

Figure 2.--Portion of clearcut burned in late fall of 1962 as seen in early spring of 1963. There is virtually no living vegetation, though charred stumps and partially burned logs are abundant. Rodent exclosure in background was used for another study.

Eight transects, two on each of four major aspects, were randomly selected in a 10-acre (4 ha.) plot on each of the three burns in early May of 1963. One sample was collected along each transect in each burned area every 2 weeks between May 10 and August 1; thereafter, on August 29 and September 26. Samples consisted of a vertical core of duff and soil 5 inches (12.75 cm.) in diameter and 8-1/2 inches (21.5 cm.) deep. Though the volume of each sample was the same, the proportion of duff and mineral soil often differed because of varying depths of the duff layer. All sampling was done during daylight hours between 8:00 a.m. and 5:00 p.m.[6]

Duff and mineral soil portions of each sample were treated differently. During each collection, the duff was removed from the surface of each core sample and the eight samples from each burn combined and transferred to one of three Berlese-type funnels where they were left for 2 weeks. The mineral soil in each core sample, kept separate by transect and date of collection, was spread out on a piece of heavy canvas where it was carefully sifted for insects and other arthropods.

ARTHROPOD ABUNDANCE IN MINERAL SOIL

The older the burn, the more individuals were found; one notable exception was the chilopods (table 1). There were about twice as many taxa represented in the 1960 and 1961 burns as in the 1962 burn.

Carabids, principally *Amara erratica* (Sturm), comprised about 66 percent of the total number of individuals collected on the 1960 burn; they were present in 35 of 72 samples. They were also found during eight of the nine sampling periods.

We found very little difference in the proportion of individuals on each of the four aspects in samples from the 1960 burn as shown in the following tabulation:

Aspect	*Percent of individuals found*
North	31
South	24
East	22
West	23

We were unable to make such a comparison with the data on the 1961 and 1962 burns because so few individuals were collected.

Arthropods were most abundant in soil samples taken during late spring and early summer (table 2). Considering all three burns, about 90 percent of the material was taken in samples collected through July 19. Ninety-six percent of the 118 carabids from the 1960 burn were found in samples collected on or before July 19.

Regardless of the year of burn or sampling date, immature specimens in the samples nearly always outnumbered the adults (table 2). In the 1960 burn, 68 percent of the total number of individuals were immatures; in the 1961 burn, 94 percent were immatures. There were no adults in the samples from the 1962 burn. Interestingly, 71 percent of the 118 carabids in the 1960 burn were immatures, both larvae and pupae.

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[6] Recently, Drake and others (1971) reported that pre-dawn appears to be the best time for sampling soil arthropods.

Table 1.--*Relative abundance of insects and other arthropods collected from samples of mineral soil on 1-, 2-, and 3-year-old burns*

Taxa	1960 burn		1961 burn		1962 burn	
	N*	T**	N	T	N	T
Coleoptera						
Carabidae						
(Principally *Amara erratica* (Sturm))	118	35	5	5	0	0
Chrysomelidae	9	4	15	3	0	0
Elateridae	1	1	4	4	2	2
Staphylinidae	2	2	0	0	0	0
Scarabaeidae	1	1	0	0	0	0
Curculionidae	10	1	2	2		
Cicindellidae	0	0	2	2		
Other	9	10	8	7	1	1
Hymenoptera	0	0	4	2	0	
Diptera	8	7	2	2	3	2
Lepidoptera	3	3	1	1	0	
Hemiptera	2	2	1	1	0	
Homoptera	6	2				
Collembola	0	0	0		2	1
Chilopoda	3	3	5	3	10	6
Diplopoda	0	0	3	2	1	1
Nematoda	5	2	1	1	4	2
Symphyla	1	1				
Total individuals	178		53		23	
Total taxa	14		13		7	

*N = the total number of individuals found in all transects at all sampling periods.

**T = the number of times, out of 72, a taxon was represented.

Table 2.--*The relative number of immature and adult arthropods collected from samples of mineral soil on 1-, 2-, and 3-year-old burns*

Date sample collected	1960 burn		1961 burn		1962 burn	
	Immature	Adult	Immature	Adult	Immature	Adult
May 10	35	1	8	0	0	0
May 23	19	3	2	0	3	0
June 6	31	15	1	1	17	0
June 20	33	10	6	2	1	0
July 5	4	5	12	0	1	0
July 19	5	7	11	0	0	0
Aug. 1	2	2	3	0	1	0
Aug. 29	1	0	4	0	0	0
Sept. 26	5	0	3	0	0	0
Total individuals	135	43	50	3	23	0

ARTHROPOD ABUNDANCE IN DUFF

Considering all taxa, the total number of individuals collected in samples from the 1962 burn was nearly half again as great as the number in samples from either the 1960 or 1961 burns (table 3). Excluding the Acarina, arthropods in samples from the 1960 burn outnumbered those from the 1961 burn by more than five times and were nearly four times more abundant than those from the 1962 burn. The number of taxa represented in duff samples from each burn was about the same.

Acarina accounted for a large percentage of the total number of individuals, regardless of the year of burn. On the 1962 burn, the mites comprised 46 percent of the total fauna; on both the 1961 and 1962 burns, about 90 percent of the organisms collected were mites. Besides the mites, the chilopods and three insect orders--Thysanoptera, Protura, and Thysanura--were most abundant on the 1962 burn.

In material collected in the duff samples, we found no consistent decreasing trend in the total number of individuals collected during late summer or early fall, as we did with the soil samples.

DISCUSSION

We suspect that the greater relative abundance of individuals on the 1960 and 1961 burns can be attributed to movement from adjacent unburned forests as well as to repopulation from survivors within the burned areas. In their work in the Southeast, Heyward and Tissot (1936) indicate that even very hot surface fires rarely heat the underlying soil to more than 176° to 194° F. (80° or 90° C.) at a depth greater than 1/4 inch (0.62 cm.) below the surface. They said: ". . .if either the animals themselves or their eggs were only 1/4 to 1/2 inch beneath the soil surface, they would stand an excellent chance of escaping harm during the fire."

However, a recent study[7] on an experimental area prescribed burned in late July during hot and dry weather in the northern Rocky Mountains showed that an extremely hot surface fire generated temperatures as high as 300° F. (149° C.) at a depth of 5/8 inch (16 mm.) on portions of the burn. No doubt most insects would have had to be deeper than 5/8 inch into the soil to survive such temperatures. However, because intensity of heat varied, average and maximum temperatures at a depth of 5/8 inch in other parts of the burn were considerably lower. Soil insects at this depth in these portions of the burn could have survived.

We did not find any ants (Hymenoptera: Formicidae) in our samples from any of the burns. Neither did we observe any ants on the burned areas. Interestingly, Heyward and Tissot (1936) found Formicidae to be the third most representative taxon (following Acarina and Collembola) in soils of a longleaf pine forest in the Southeast. In a study in New Jersey, several species of Formicidae comprised 93 percent of the total number of individuals on a burned area and 96 percent of the individuals on an unburned area (Buffington 1967).

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[7] R. C. Shearer. Soil moisture, soil temperature, and root mortality associated with prescribed burning in western larch forests. Intermountain Forest and Range Exp. Sta., Ogden, Utah 84401. (In preparation).

Table 3.--*Relative abundance of insects and other arthropods collected from samples of duff on 1-, 2-, and 3-year-old burns*

Taxa	1960 burn		1961 burn		1962 burn	
	N*	T**	N	T	N	T
Coleoptera						
Carabidae (Principally *Amara erratica* (Sturm))	26	7	2	2	1	1
Curculionidae	1	1	2	1	0	0
Staphylinidae	6	4	2	2	1	1
Other	35	8	26	7	27	7
Collembola						
Sminthuridae	7	4	1	1	0	0
Entomobryidae	88	7	13	4	5	4
Poduridae	246	8	10	4	5	4
Diptera	13	5	8	4	4	3
Lepidoptera	5	4	1	1	0	0
Hymenoptera	32	5	1	1	2	2
Hemiptera	26	5	0	0	3	1
Homoptera	26	9	2	1	6	1
Thysanura	7	3	5	3	18	5
Protura	3	2	0	0	19	2
Thysanoptera	14	6	20	5	29	2
Acarina	475	9	929	8	1,260	9
Araneae	9	4	3	2	8	2
Chilopoda	7	4	5	3	22	4
Nematoda	1	1	0	0	0	0
Symphyla	0	0	0	0	1	1
Pseudoscorpionida	0	0	0	0	4	1
Total	1,027		1,030		1,414	
Total (without Acarina)	552		101		154	
Total taxa	19		16		17	

*N = the total number of individuals found in all transects at all sampling periods.

**T = the number of sampling periods, out of 9, when a taxon was represented.

Of particular interest to us was the abundance of carabids, principally *Amara erratica*, in both the mineral soil and duff samples from the 1960 burn when compared to the scarcity of these beetles in samples from the 1961 and 1962 burns (tables 1 and 3). Such relative population differences could indicate decimation of *A. erratica* populations by the prescribed burning and a resurgence of the species 3 years later.

In another phase of our studies that concerned insects affecting western white pine following direct seeding on these same prescribed burns, we found *A. erratica* to be the principal seed destroying insect (Kennedy and Fellin 1969). In this study, we often observed and collected it on our study plots on the 1960 burn. A projection based on sample data from the 1960 burn indicates that there could have been up to 100 carabids per square yard (91.5 $cm.^2$) of soil surface.

Since our study was completed in 1963, direct seeding of western white pine has been discontinued (Ketcham, Wellner, and Evans 1968). If it's resumed, however, we feel that seeding should be done the first or second year following burning. After that, increasing carabid populations could substantially reduce the probability of successful regeneration. Our data indicates that carabids not only increase in number by the third year following burning, but that they are most abundant early in the season when seeds are lying in the duff or on the soil surface before germination. We speculate that these carabids will also eat seeds of other coniferous species, such as grand fir (*Abies grandis* (Dougl.) Lindl.), and western redcedar (*Thuja plicata* Donn), growing in association with western white pine as well as seeds of conifers not associated with western white pine. If so, any direct seeding programs for these species should also be planned for the first year or two following prescribed burning.

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